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H. J. DAILEY

2,396,772

ELECTRONIC DISCHARGE DEVICE

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Fig. 1.

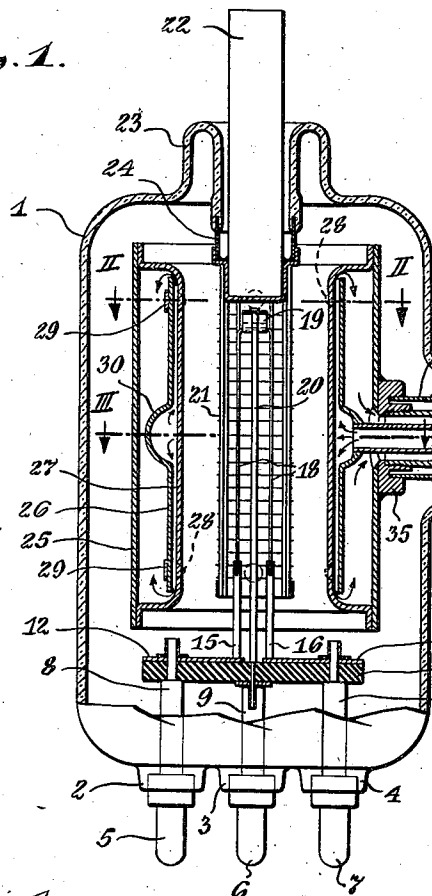


Fig. 2.

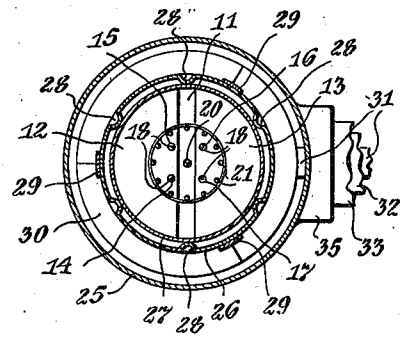


Fig. 3.

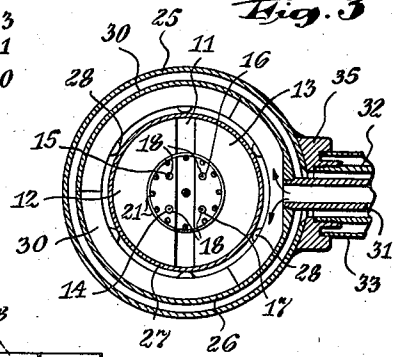


Fig. 4.

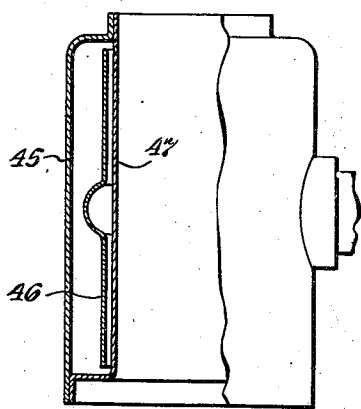
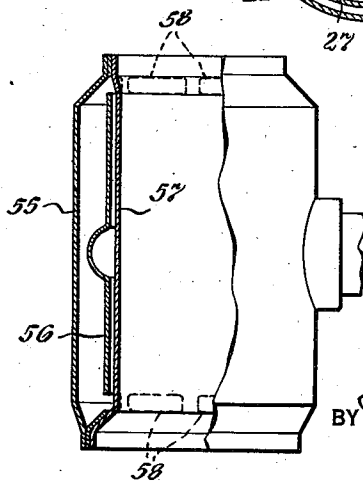


Fig. 5.



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## UNITED STATES PATENT OFFICE

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## ELECTRONIC DISCHARGE DEVICE

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4 Claims. (Cl. 250—27.5)

My invention relates to electronic discharge devices and more particularly to water-cooled high power tubes for high frequency service.

The known discharge tubes with water-cooled electrodes, in particular internally cooled anodes, have some shortcomings peculiar to the electrode constructions and cooling means heretofore available.

One of these shortcomings is the relatively low efficiency of these tubes at frequencies in the order of 40 megacycles and above. This inefficiency at high frequencies is due to the long leads required in the known water-cooled tube constructions and to the additional tube inductance and capacitance caused thereby. The same causes are apt to render the tube operation rather unstable at high frequencies.

Another disadvantage of the known high power tubes with cooled anodes is the necessity of providing large-diameter metal-to-glass seals, thereby adding to the difficulties and cost of manufacturing the tubes.

It is an object of my invention to provide high power tubes with internally cooled anodes which avoid the above-mentioned deficiencies of the known discharge devices of this kind.

More specifically, the invention aims at providing a highly effective cooling of an anode by passing a cooling agent from the outside of the tube envelope through the anode structure while reducing the length of the electrode leads to a minimum in order to increase the efficiency and stability of the tube operation.

Another object of the invention is to provide a water-cooled anode within a sealed envelope while requiring only small diameters for the metal-to-glass seals between the electrodes, in particular the water-cooled hollow anode, and the envelope.

Still another object lies in the provision of incoming and outgoing conduit means for circulating a cooling agent from the outside of a vitreous tube envelope through a hollow anode structure and reducing the metal-to-glass connection of the anode structure and both appertaining conduits to a single seal.

It is also an object of the invention to provide a simplified and improved construction of a hollow anode with appertaining fluid conduits for cooling agent, which ensures a thorough and even cooling effect of the entire effective discharge surface of the anode while being simple to manufacture in line with the other advantages and objects previously mentioned.

To accomplish these objects, and in accordance with the present invention, I provide within the

sealed envelope of a discharge device a centrally arranged cathode and a substantially cylindrical anode surrounding the cathode, and construct this anode in the form of a hollow jacket with a cylindrical partition or baffle placed between the inner and outer jacket walls so as to form two concentric jacket spaces. These spaces communicate with each other near both axial ends of the jacket for the passage of cooling agent from one to the other space. Also according to my invention, two concentric fluid conduits or tubes are provided for circulating the cooling agent through the jacket. These conduits pass together through the wall of the envelope and are connected with the outer and inner jacket space respectively.

In accordance with another feature, the just-mentioned concentric conduits extend substantially in a radial direction relative to the anode jacket and leave the tube envelope through its peripheral wall, while the cathode leads pass through one of the axial ends of the envelope. When applying the invention to grid-controlled tubes, the grid lead extends also axially but is arranged at the other end of the envelope so that the conduits, cathode lead and grid lead form a substantially T-shaped arrangement.

These and other objects and features of the invention will be apparent from the following description of the embodiments shown in the drawing in which Figure 1 represents a longitudinal sectional view of a complete disclosure tube according to the invention, Figs. 2 and 3 show two cross sections of the electrode assembly of the same tube taken along the two respective planes denoted in Fig. 1 by the dot-and-dash lines marked II and III, while Figs. 4 and 5 show in part-section two different modifications of the water-cooled anode structure to be used in tubes otherwise similar to that of Fig. 1.

Referring to Figs. 1, 2 and 3, the vacuum-tight enclosure of the illustrated discharge tube is denoted by 1. The enclosure consists preferably of glass or other vitreous material and has an elongated substantially cylindrical shape. Three stems 2, 3 and 4 are provided at one axial end of the envelope for accommodating and sealing three respective terminals 5, 6 and 7. The upper ends 8, 9 and 10, respectively, of these terminals carry an insulating plate 11 which forms a base for the cathode structure.

Two approximately semicircular metal plates 12 and 13 are mounted on the insulating base 11, each carrying two conductive holders 14, 15 and 16, 17 respectively. Two cathode filaments

18 have their ends attached to the holders while their central portions are passed over a metallic support 19 which is suspended from a rod-shaped central holder 20 also of metal. The holder 20 traverses the insulating base 11 and is connected with end 9 of terminal 6 so as to form a center tap as regards the filaments 18. The just-mentioned cathode structure extends substantially in the longitudinal axis of the envelope.

A grid assembly 21, here exemplified by a cage-like structure composed of longitudinal rods and peripheral wires, is arranged coaxially to the cathode structure. It is connected with a grid lead 22 which passes through a re-entrant neck portion 23 of the envelope 1 to the outside at the axial end of the envelope opposite to the above-mentioned terminals 5, 6 and 7. A metal sleeve 24 serves to provide a vacuum-tight metal-to-glass seal between the grid assembly and the envelope 1.

The anode structure is composed of three concentric cylinders 25, 26 and 27 which are nested in one another and arranged so as to surround the cathode structure and grid assembly along the entire periphery of the arrangement. The outer cylinder 25 is of straight cylindrical shape while the inner cylinder 27 has its axial ends bent towards the outer cylinder 25 and sealed thereto in a vacuum-tight manner. The intermediate cylinder 26 is spaced from the outer and inner cylinder and at both ends shorter than the latter cylinders. Suitable spacing knobs or protuberances 28 integral with cylinder 26, are provided for maintaining the proper spacing. For the purpose of convenient manufacture the cylinder 27 is composed of three sectors whose longitudinal edges abut and the sectors joined together by means of small cleats 29 which are placed over the butt joints and welded to the two adjoining sectors.

Due to the just-mentioned arrangement, the cathode structure forms a cylindrical hollow jacket for the circulation of a cooling agent such as water, and the cylinder 27 forms a baffle for guiding the flow of cooling agent along the anode surface walls and from one to the other jacket space. In order to obtain most favorable cooling conditions, the central portion of the composite inner cylinder 27 forms a bulge at 30 so as to offer a larger volume region at the inlet place of the cooling agent. Due to the fact that the cylindrical path of fluid flow between cylinders 26 and 27 is rather narrow in the two axial end sections of the structure, these sections form a high velocity region for the fluid flow. As a result, the turbulence in these latter regions is increased so that steam bubbles, should they occur, are more safely swept away than would be the case with a non-turbulent flow of cooling agent.

Two concentric conduits of tubular shape, denoted by 31 and 32, are provided for supplying the anode jacket with cooling agent. The inner tube 31 is connected with the baffle cylinder 26 so as to open into the large volume region of the jacket space within the cylinder 26. The outer tube 32 is connected with the outer anode cylinder 25 and opens into the outer jacket space. The concentric tubes 31 and 32 extend substantially in a radial direction relative to the anode structure and envelope and traverse the peripheral wall of the envelope. A metal sleeve 33, arranged concentrically to the tubes 31 and 32, is

sealed to the outer anode cylinder 25 and to a re-entrant branch portion 36 of the envelope 1 in order to establish a vacuum-tight metal-to-glass seal and serves also for supporting the anode structure. The tubes 31, 32 and the sleeve 33 are located substantially near the center portion of the anode structure. Both tubes 31 and 32 are of metal, and one or both of them serve also as an electric anode lead. For reasons of convenient manufacture and assemblage, an annular metal body 35 is interposed between the cylinder 25 and the sleeve 33 and tightly welded or soldered to these two elements. The body 35 has an inner thread engaged by the threaded end of tube 32. The other end of the tube 32 is closed by an attachment 36 which forms the anode terminal for connection with the plate circuit of the device and may also serve as an additional support for the device. A branch pipe 37 attached to tube 32 forms the necessary outlet for the cooling agent.

When in operation, the cooling agent is supplied through the inner tube 31 as indicated by the arrow 38 and reaches at first the large volume region of the inner jacket space within the baffle cylinder 26. Thence it flows in upward and downward directions through the high velocity regions to the edges of the cylinder 26 and into the outer jacket space as is indicated by a group of arrows (not marked by reference numerals). From this outer space the cooling agent is withdrawn through the outer tube 32 and its outlet branch 37 as is indicated by the arrow 39. Thence, if desired, the cooling agent is passed through an exterior circulation system (not shown) where it is cooled to a low temperature before being forced back into the supply conduit 38.

Fig. 4 illustrates a modified form of an anode construction applicable in accordance with the invention instead of the anode structure illustrated in Fig. 1. According to Fig. 4, the inner cylinder 47 of the structure is straight cylindrical at its upper end while the outer cylinder 55 is constricted, as by having its upper end tapering towards the inner cylinder. This constricted end of the outer cylinder is tightly sealed to a straight cylindrical end of the inner cylinder in order to provide a cylindrical jacket space which, similar to the embodiment of Fig. 1, is subdivided into an inner and outer annular space by an intermediate baffle cylinder 33. The baffle cylinder may be made in this modification as an entity without subdivision into segments as necessary in the previously described constructions.

According to the modification shown in Fig. 5, both the inner cylinder 57 and the outer cylinder 55 have their axial edges bent towards each other while the baffle cylinder 56 is straight cylindrical at both ends, and extends between the edges of the outer and inner cylinder. As with the construction of Fig. 4, the several cylinders may be telescoped to place in the modification of Fig. 5 so the baffle cylinder is conveniently a one-piece construction. The edges of the three cylinders are welded or otherwise tightly sealed together to provide the jacket space for the cooling agent. The baffle cylinder 56 has a number of openings 58 near its axial ends in order to provide a passage for the cooling agent from the inner to the surrounding outer space of the anode jacket.

In both embodiments of Figs. 4 and 5, the tubular conduits for the circulation of cooling agent through the jacket are arranged and constructed

similar to the first described construction as explained in connection with Fig. 1. It will be noted, however, that the cylinder arrangements according to both Figs. 4 and 5 are so shaped and proportioned that the baffle cylinder 46 or 56 may be designed as a single-piece structure because it can be slipped over one end of the inner cylinder 47 or 57 before assembling both with the outer cylinder.

It will be seen from the above-described examples that the invention provides an effective cooling device for the anode of a high power tube while permitting the electrode leads to have minimum lengths. This advantage is mainly due to the fact that the anode structure and its appertaining lead do not occupy any space in front of the openings of the cooling jacket and that the cathode and grid leads extend out of the discharge tube along the shortest way possible. The anode lead, formed by one or both of the tubular conduits 31 and 32, is likewise of minimum length and extends at a right angle to the leads of cathode and grid, thus forming together with these other leads a generally T-shaped arrangement. As a result, a discharge device according to the invention combines an effective cooling device with extremely short leads and in this respect is superior to the known devices of comparable design and operation.

It will also be seen from the examples that only one metal-to-glass seal is required between the anode structure and the envelope and that this seal can be kept at extremely small dimensions as compared with the diameter or size of the anode. This is due to the above-described use of concentric supply conduits for the cooling agent of a single sealing sleeve 33 surrounding both conduits. The absence of large metal-to-glass seals near the axial ends of the anode has the further advantage that it permits the filament and grid assemblies to be arranged very close to the anode.

While I have shown only three different embodiments of my invention, it will be obvious therefrom to those skilled in the art that other alterations and modifications can be made without departing from the essence of the invention as set forth in the claims following hereafter.

I claim as my invention:

1. An electron discharge tube having an envelope, a cathode, and an anode structure surrounding said cathode in said envelope, said anode structure having two substantially cylindric and coaxial walls radially spaced from each other and connected with each other at their axial ends to form a cooling jacket, a cylindric baffle within said jacket coaxial therewith and having a peripheral bulge midway of its length with the crest of the bulge spaced from the outer of said walls a distance substantially equal to the spacing of said baffle from the inner wall, and the cylindric parts of said baffle away from said bulge having closer spacing to the inner wall than to the outer wall thereby providing an acceleration channel, and means for introducing fluid to and removing the same from said jacket at opposite sides of the bulge of said baffle, whereby copious fluid supply is present at the mid-portion of the jacket in the bulge and acceleration of flow is produced therefrom through the close-spaced acceleration channel.

2. An electron discharge tube having an envelope, a cathode, and an anode structure surrounding said cathode in said envelope, said anode structure having two substantially cylindric and coaxial walls radially spaced from each other and connected with each other at their axial ends to form a cooling jacket, a cylindric baffle within said jacket coaxial therewith and having a bulge midway of its length forming a reservoir for supply of cooling fluid to the jacket from the reservoir in both longitudinal directions of the jacket, and the cylindric parts of said baffle away from said bulge having closer spacing to the inner wall than to the outer wall thereby providing an acceleration channel, and means for introducing fluid to and removing the same from said jacket at opposite sides of the bulge of said baffle, whereby copious fluid supply is present at the mid-portion of the jacket in the bulge and acceleration of flow is produced therefrom through the close-spaced acceleration channel.

3. An electron discharge tube having an envelope, a cathode, and an anode structure surrounding said cathode in said envelope, said anode structure having two substantially cylindric and coaxial walls radially spaced from each other and connected with each other at their axial ends to form a cooling jacket, a cylindric baffle within said jacket forming jacket spaces inside and outside of the baffle, said baffle having a bulge midway of its length protruding in the outside jacket space, said bulge and outer cylindric wall providing fluid passageway between the longitudinal cylindric end parts of the jacket past the bulge in said outside jacket space, and the cylindric end parts of said baffle away from said bulge having closer spacing to the inner wall than to the outer wall thereby providing an acceleration channel, and means for introducing fluid to and removing the same from said jacket at opposite sides of the bulge of said baffle, whereby copious fluid supply is present at the mid-portion of the jacket in the bulge and acceleration of flow is produced therefrom through the close-spaced acceleration channel.

4. An electron discharge tube having an envelope, a cathode, and an anode structure having two substantially cylindric and coaxial walls radially spaced from each other and connected with each other at their axial ends to form a cooling jacket, a cylindric baffle within said jacket coaxial therewith and having a peripheral bulge midway of its length with the crest of the bulge spaced from the outer of said walls a distance substantially equal to the spacing of said baffle from the inner wall, and the cylindric parts of said baffle away from said bulge having closer spacing to the inner wall than to the outer wall thereby providing an acceleration channel, an inlet conduit for introducing fluid to the interior of said bulge whereby copious fluid supply is present at the mid-portion of the jacket in the bulge and acceleration of flow is produced therefrom through the close-spaced acceleration channel, and an outlet conduit of greater cross-sectional area than the inlet conduit opening into the space between the outer of said cylindric walls and the baffle for removing the fluid from the jacket without materially retarding flow of the fluid in the acceleration channel.

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